L2 ARG Edition 1 Validation report (including G2 SWupdate):

GERB project team, last update January 2018

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Please cite: Harries et al. 2005 when referencing GERB data.

Contents

Definition of terms

GERB – Geostationary Earth Radiation Budget instrument (Harries et al. 2005). Broad band radiometer on the geostationary METEOSAT second generation satellites. GERB 2 was the first instrument launched on METEOSAT-8 and provided operational data from 2004 to 2007. GERB 1 on METEOSAT-9 provided operational data from 2007 to 2013.

CERES – Clouds and the Earth's Radiant Energy System instruments. Broad band radiometer to measure the radiative energy budget at the top of the atmosphere from low earth orbiting platforms including the TERRA and AQUA sun synchronous satellites.

Level 2 ARG data – GERB Averaged, Rectified, Geolocated products. Three scan averaged calibrated unfiltered radiances and fluxes on a regular grid, contains effect of instrument point spread function.

PSF – Point Spread Function. Describes the spatial variation in the weighting of the GERB pixel footprint.

SEVIRI – Spinning Enhanced Visible and Infrared Imager. A meteorological imager on each of the Meteosat Second Generation satellites which observes the Earth in 11 narrow-band spectral channels every 15 minutes with a sub-satellite sampling distance of 3km.

SW and TOT – abbreviations used to denote respectively the shortwave and total channels of the GERB radiometer including the weighting of the spectral response.

LW – abbreviation used to denote the synthetic longwave channel, created by the weighted subtraction of the SW from the TOT. It includes the spectral weighting of the synthetic channel response.

RSW and OLR – abbreviations for Reflected Shortwave and Outgoing Longwave Radiation, used to explicitly denote the reflected solar and emitted thermal radiation streams respectively.

1. Validation result summary ARG release (G2 SWupdate 2011):

The section reports the validation studies performed for the ARG release, including the SWupdate calibration adjustment for the GERB 2 products. Results do not include the combined correction adjustments for aging or the difference between the two instruments. Comparisons with CERES are the SSF Ed2 CERES products with the rev 1 correction..

The CERES instruments (Wielicki et al. 1996) flying on the low Earth orbit AQUA and TERRA satellites measure the outgoing longwave and reflected shortwave broad band radiances and fluxes in a similar manner to GERB. Their products have been extensively validated and have stated absolute accuracy of 1.0% for the shortwave 0.5% for the longwave radiances.

Calibration offsets:

Validation studies have compared the GERB ARG radiances and fluxes with CERES SSF rev1 radiances and fluxes. In addition an extensive inter-comparison of the GERB 1 and GERB 2 data has been made. The resulting average GERB/CERES and GERB 2/ GERB 1 ratios are shown in the figures below. The CERES data used was the SSF Edition 2 dataset with the rev 1 allsky corrections applied. Data points are matched temporally (within 15minutes) and spatially and in the case of radiances viewing geometry is also matched to within 5°. Daily averages of all the matched points are calculated and then the ratio determined from the daily average values. The average ratio over all days of the comparison period and associated standard deviation is calculated. Values shown in figures 1 and 2 are these average ratios, the error bars indicate $3\sigma / \sqrt{ndays - 1}$. More detail on the comparison methodology and further results for the GERB 2 CERES 2004 comparisons are provided in Clerbaux et al. (2009). Note in the table below the SW calibration update has been applied to the GERB 2 Edition 1 data, this was not applied in the comparisons shown in Clerbaux et al. (2008).

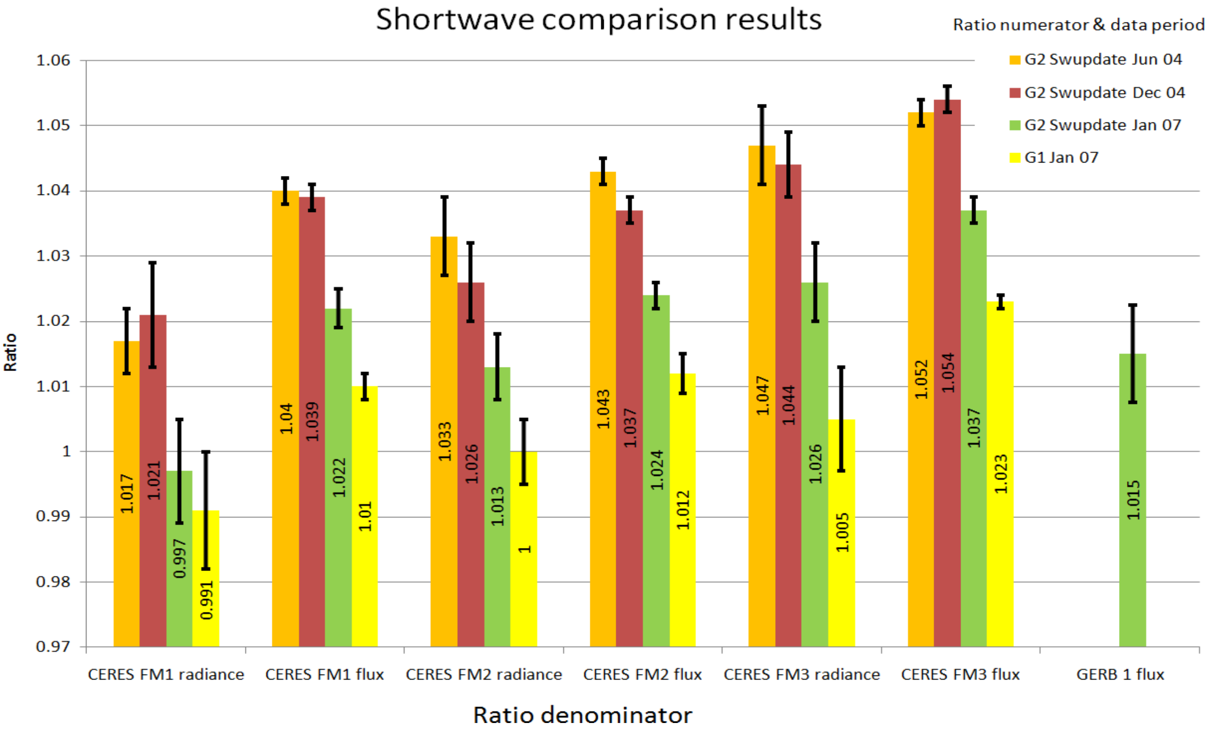

Figure 1. Summary of comparison results average shortwave ratios shown, data used denominator and whether flux or radiance is compares is shown on the x-axis, data used in the numerator and the time period of the comparison is indicated in the legend. Ratios are calculated from the mean of matched points each day, the mean ratio is then determined over the whole period and its associated standard deviation calculated. Error bars show the 3σ uncertainty based on the variability in the individual ratios calculated. All GERB 2 data have the SW calibration update applied, results shown for GERB 2 for June and December 2004 are taken from Clerbaux et al. 2008 and adjusted to account for the GERB 2 SW calibration update.

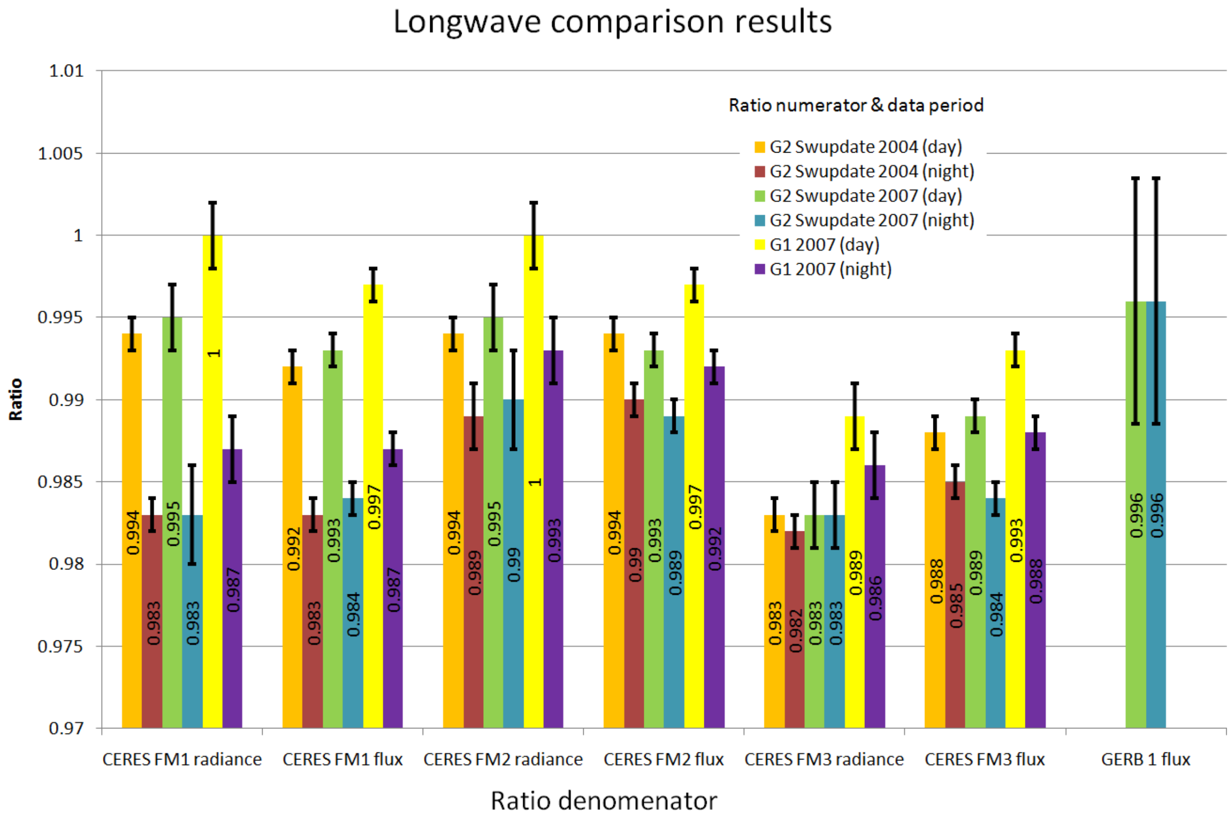

Figure 2. Summary of comparison results average longwaye ratios shown, data used denominator and whether flux or radiance is compares is shown on the x-axis, data used in the numerator and the time period of the comparison is indicated in the legend. Ratios are calculated from the mean of matched points each day, the mean ratio is then determined over the whole period and its associated standard deviation calculated. Error bars show the 3σ uncertainty based on the variability in the individual ratios calculated. All GERB 2 data have the SW calibration update applied, results shown for GERB 2 for June and December 2004 are taken from Clerbaux et al. 2008 and adjusted to account for the GERB 2 SW calibration update.

The shortwave ratios shown in figure 1, display a difference between the radiance and flux ratios which implies that there are two aspects to the GERB / CERES ratio. The first, indicated by the co-angular radiance comparison relates to a calibration difference between the instruments and the second, resulting in around an extra 1% elevation is due the effect of differences between the scene identification and radiance to flux conversion.

In 2007 the calibration difference between GERB 1 and CERES is seen to within the uncertainty of the comparison (<1%). The GERB 2 / GERB 1 difference in 2007 shows GERB 2 to be about 1.5% higher in the shortwave. However the GERB 2 CERES comparisons shows an evolving picture. The difference between GERB 2 and CERES in 2007 varies with CERES flight model from 0 to 2.6%. The 2004 comparisons between GERB 2 and CERES show GERB 2 to be around an extra 2% higher than each CERES flight model on top of the difference found in 2007, implying a change in the relative calibration of the two instruments over time.

From the longwave ratios in figure 2 we see consistent results for GERB 2 in 2004 and 2007. Daytime comparisons for both GERB 1 and GERB 2 radiance and flux show agreement to within 1% between GERB and CERES (apart from FM3) and between the two GERB instruments. Night-time differences are slightly larger but still within 1.5% for FM2 and within 2% for FM1 and FM3. When considering the cause of the discrepancy between the day night results two things must be borne in mind. Firstly in the day the longwave is obtained by a

subtraction of the shortwave channel measurement from a total observation for both GERB and CERES. This process must account for a calibration difference between the channels which if not done correctly will result in differing day night errors. However during the night there is a greater proportion of cold scenes comprising the average and thus a variation of the calibration offset between the two instruments with scene temperature can also result in a day night difference. Decomposing the day-night comparisons according to the scene radiance indicates that it is a combination of these effects. Ratio tend to reduce with reducing scene radiance during both day and night and the greater prevalence of colder scene at night reduces the overall ratio, however even for the same scene temperature ratios are generally lower at night than in the day.

Spatial comparisons:

Comparison maps of the ratio for averages over all the matched data for both radiance and flux have been made where there is sufficient data. The radiance comparisons allow spatial patterns due to a calibration variation as a function of pixel and viewing angle to be highlighted. In addition to this the flux comparisons highlight deficiencies with the angular modelling of the radiance to flux conversion. It should be noted that these maps are not comparison of monthly average products but are averages of instantaneously matched data points and thus subject to the time constraints of the CERES overpasses.

In figure 3 we can see the problems with the longwave radiance to flux conversion associated with thin cloud (see specific cautions) in the GERB 2 / CERES all sky flux ratios shown in the third column, whereas no such effect is seen in the radiance comparisons and is much reduced in the clear sky flux comparisons shown in this figure.

Figure 4 shows the same for the shortwave comparisons. Here some spatially varying calibration differences are observed which is likely a combination of GERB pixel to pixel variability in calibration (~2%) and the effect of different calibration offsets as a function of scene (a spectral response effect). The flux results show some coherent patterns associated with differences in scene ID and consequently radiance to flux conversion. The different treatment of aerosol between GERB and CERES in the radiance to flux conversion is also likely contributing tot he differences seen particularly off the West Coast of Africa.

GERB 1 / CERES spatial flux ratio plots are shown in figure 5 and indicate similar effects to those already discussed for GERB 2.

For the GERB 2 GERB 1 comparisons the increased matches allow us to decompose the results further according time of day. This is shown in figure 6 for the longwave and figure 7 for the shortwave. The longwave shows little variation outside the ±1% range except in the northern extreme in the day where the cold bright scenes highlight the effect of differing accuracy of the subtraction of the shortwave component and at all times of day across the ITCZ where the variation of the calibration offset with scene temperature results in reduced ratios. The shortwave comparisons which are further decomposed into all sky, overcast and clear sky. Here variations with scene and time of day particularly in the clear sky highlight the limitations of the radiance to flux conversion and the effects of the subtly differing viewing position of the instruments. The overcast comparisons also indicate a difference between the scene identification particularly at more extreme solar angles. These effects will all introduce a step in the data record at the point of transition. They will be considered within the planned Edition 2 improvements, until that time extreme caution is advised in using these two data records in combination.

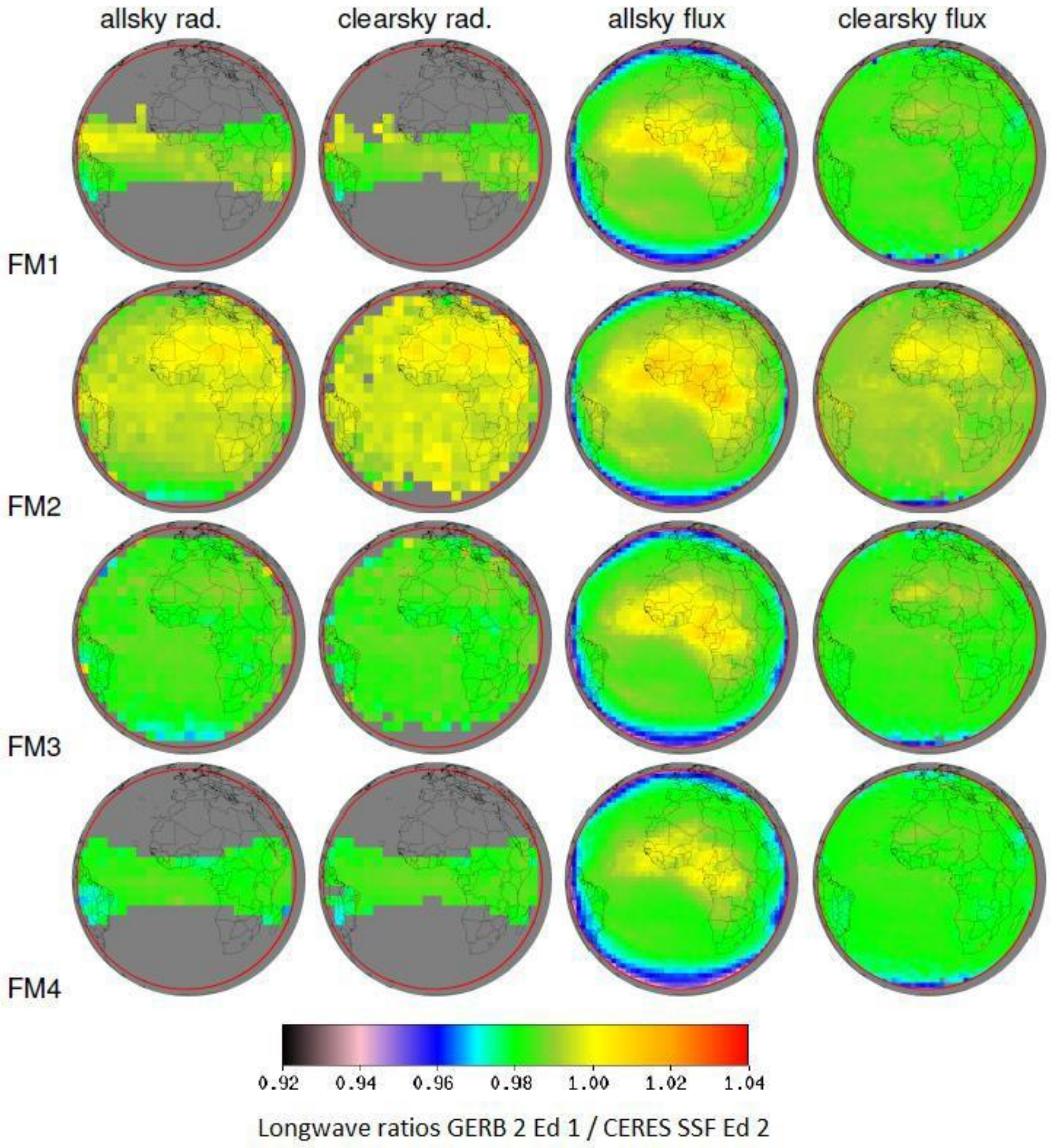

Figure 3: GERB 2 Ed 1 / CERES SSF Ed 2 longwave flux ratio for June and December 2004 temporally and spatially matched points plus angular matching for radiances. First and third columns show all sky comparisons for radiance and flux respectively, second and forth columns clear sky matches for radiance and flux. Reproduced from Clerbaux et al. 2009, see paper for methodology.

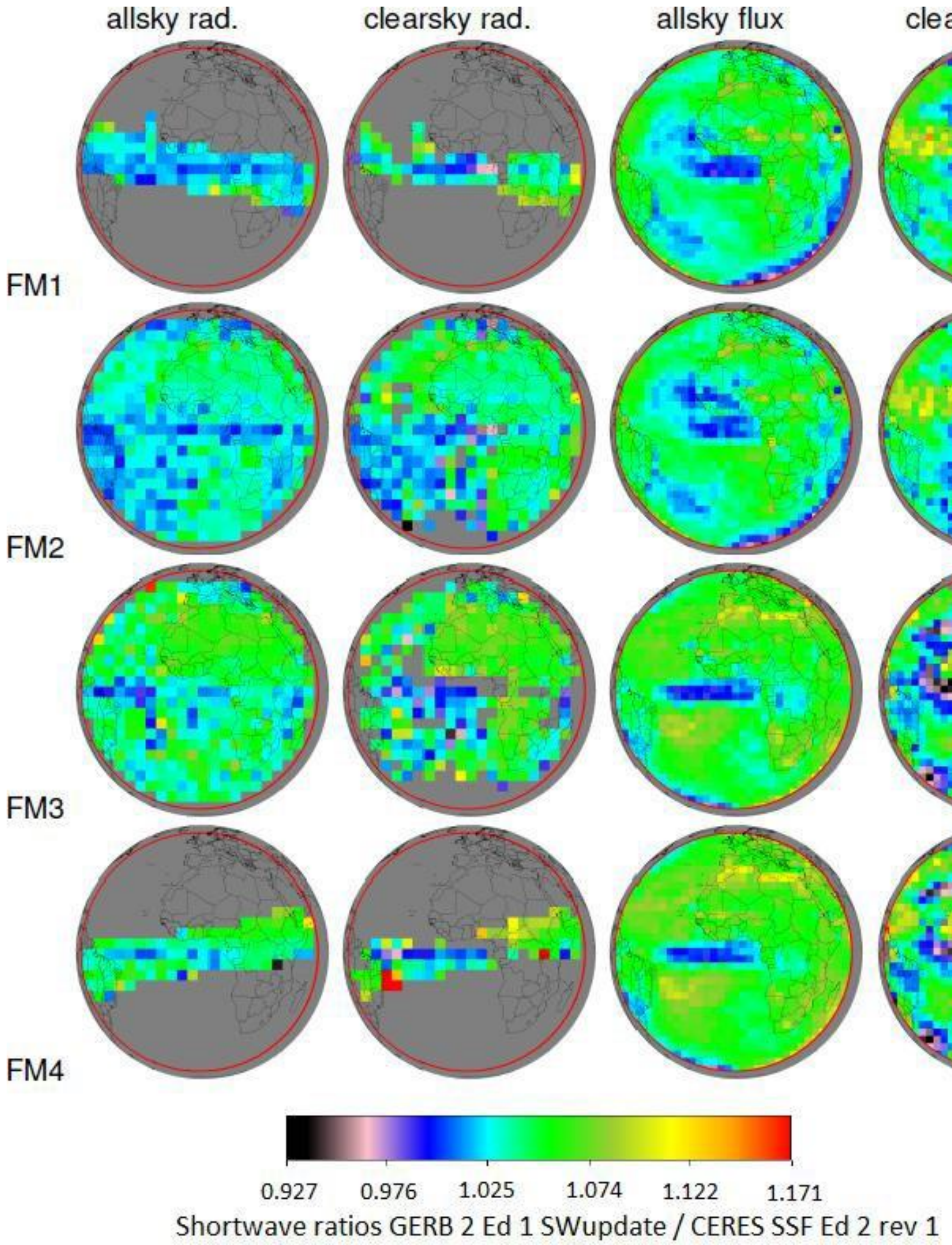

Figure 4: GERB 2 Ed 1 / CERES SSF Ed 2 longwave flux ratio for June and December 2004 temporally and spatially matched points plus angular matching for radiances. First and third columns show all sky comparisons for radiance and flux respectively, second and forth columns clear sky matches for radiance and flux. Reproduced from Clerbaux et al. 2009 but scale adjusted here to account for the GERB 2 shortwave calibration update, see paper for methodology.

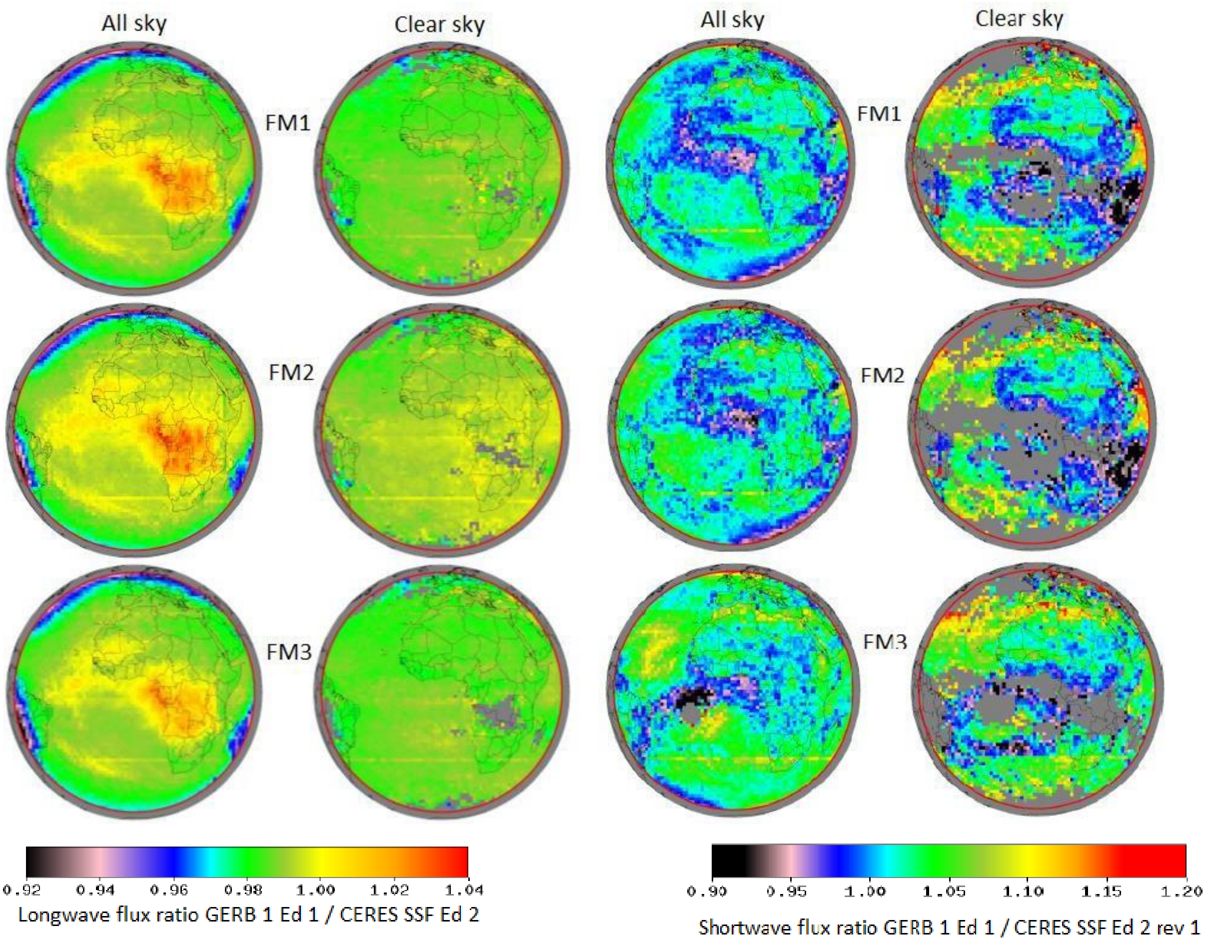

Figure 5: GERB 1 Ed 1 / CERES SSF Ed 2 longwave (first and second column) and shortwave (third and forth column) flux ratio for January 2007 temporally and spatially matched points. First and third columns show all sky, second and forth columns clear sky, tow row are CERES FM1, middle row CERES FM2 and bottom row CERES MF3. Methodology follows that described for GERB 2 comparisons shown by Clerbaux et al. 2009.

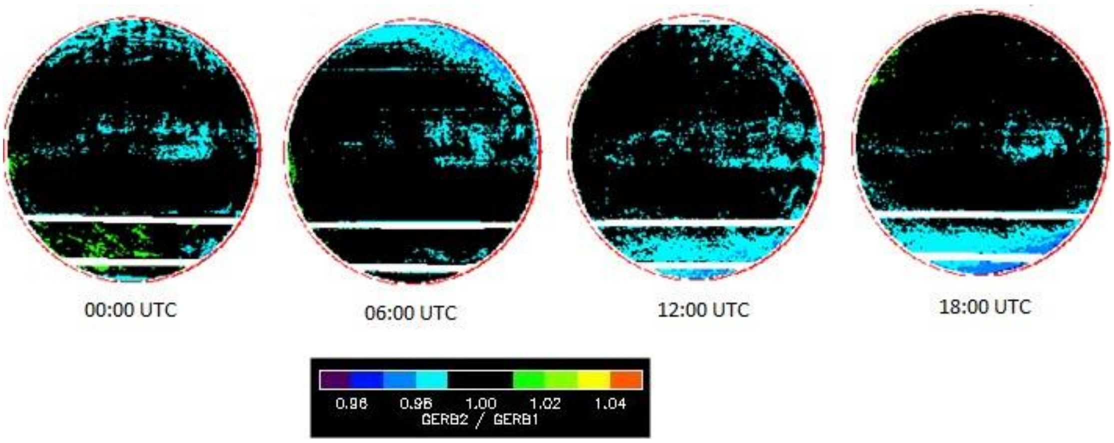

Figure 6. Longwave G2/G1 average ratio plots for May 2007, for 4 times of day.

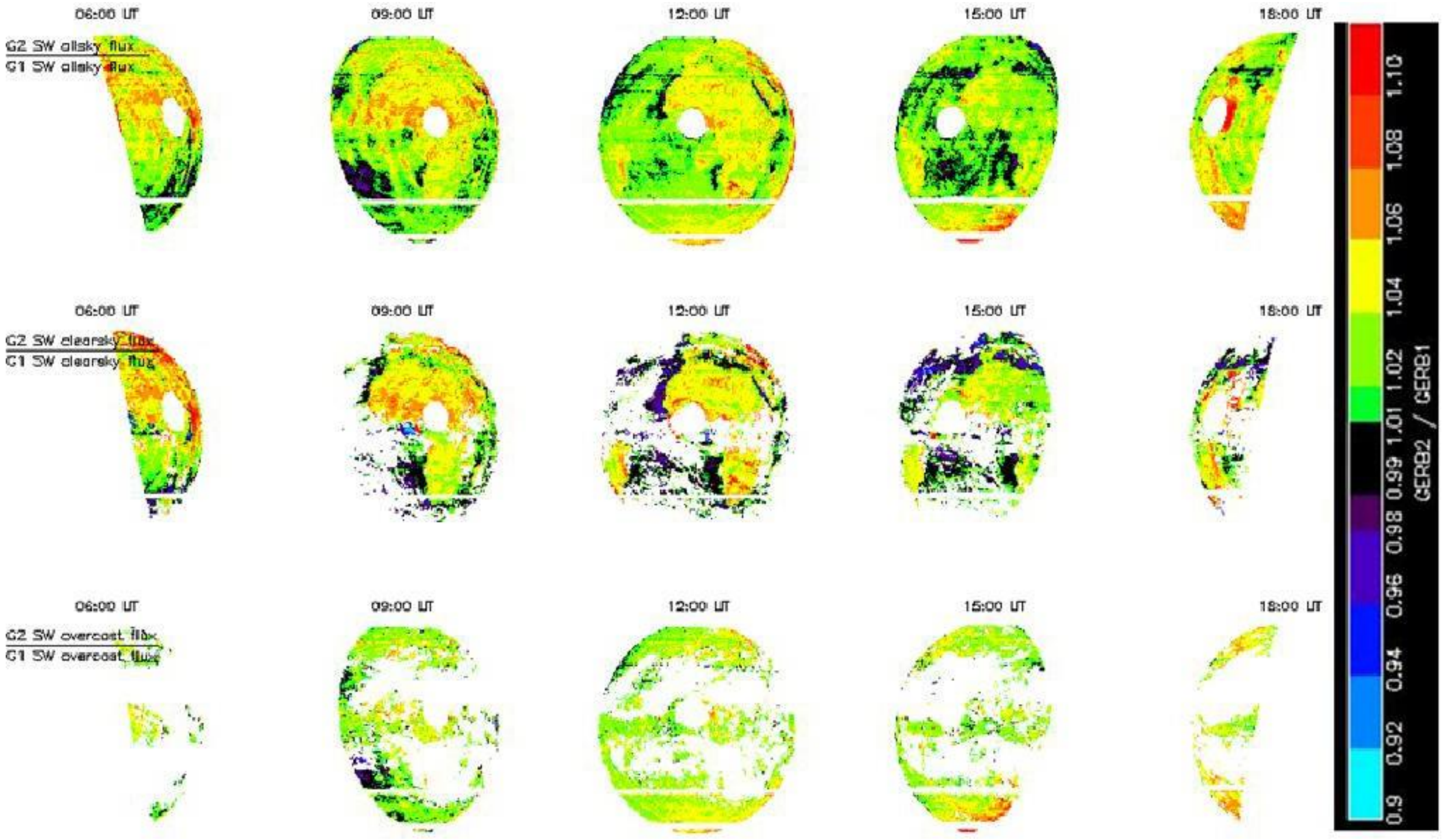

Figure 7. Shortwave G2/G1 average ratio plots for May 2007, for 5 times of day, decomposed according the GERB scene ID into allsky, clearsky and overcast.

2. References

Clerbaux, N. J. E. Russell, S. Dewitte, C. Bertrand, D. Caprion, B. De Paepe, L. Gonzalez Sotelino, A. Ipe, R. Bantges, H. E. Brindley. 2009. Comparison of GERB instanteous radiance and flux products with CERES Edition-2 data. Remote Sens. Of Environ. 112: 102-114.

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N. Clerbaux, S. Dewitte, C. Bertrand, D. Caprion, B. De Paepe, L. Gonzalez, A. Ipe and J.E. Russell (2008b): Unfiltering of the Geostationary Earth Radiation Budget (GERB) Data. Part II: Longwave Radiation, *Journal of Atmospheric and Oceanic Technology*, **25(7)**, 1106-1117.

Wielicki, B. A., B. R. Barkstrom, E. F. Harrison, R. B. Lee III, G. L. Smith, and J. E. Cooper, 1996: Clouds and the Earth's Radiant Energy System (CERES): An Earth Observing System Experiment, Bullietin of the American Meteorological Society, 77, 853-868.

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3. Further information and user documents

The following applicable documents contain further relevant details and are available from the GERB edition data distribution archives:

the GERB edition data distribution archives:

Quality Summary: GERB level 2 Edition 1: [this document] Essential information for users of the GERB products, required reading.

Product processing and accuracy summary: Updated document describing the GERB processing and providing theoretical accuracy statements of the data fields. Recommended reading for all users of the GERB data. Includes sections of the aging and the treatment of fill fields of relevance to the latest release.

Level 2 ARG Edition 1 release validation report: Validation studies completed at the time of the ARG edition 1 release. Includes comparison with older CERES products (CERES SSF Ed 2). Incorporates the required user applied ground calibration update for GERB 2 comparisons, but does not include the latest recommended user revisions that unify and stabilise the GERB records.

Level 2 HR Edition 1 release validation supplement: Latest validation for the filled HR and BARG Edition 1 release. Comparisons with later versions of CERES data (CERES SSF Ed 3 and Ed 4). Consideration of the filled data and the latest user revisions for aging and unification of the record.

RMIB GERB products user guide: automatically generated document detailing every field contained in all the GERB level 2 products.

Quality Summary for GERB Edition 1 L1.5 NANRG and GEO products: NANRG release quality and validation document. As the level 1.5 products form the basis of the level 2, users of the level 2 may find the information useful background.

GGSPS products user guide: provides background information on product definitions relevant to all products and details of the parameters contained in the level 1.5 GERB data